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United States Patent [19]

Blomquist

[11] **Patent Number: 6,024,539**

[45] **Date of Patent: *Feb. 15, 2000**

[54] **SYSTEMS AND METHODS FOR COMMUNICATING WITH AMBULATORY MEDICAL DEVICES SUCH AS DRUG DELIVERY DEVICES**

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[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

[21] Appl. No.: **08/868,913**

[22] Filed: **Jun. 4, 1997**

Related U.S. Application Data

[63] Continuation of application No. 08/586,952, Jan. 16, 1996, abandoned, which is a continuation of application No. 08/276,025, Jul. 15, 1994, Pat. No. 5,485,408, which is a continuation of application No. 07/942,288, Sep. 9, 1992, Pat. No. 5,338,157.

[51] **Int. Cl.**[7] **F04B 41/06**

[52] **U.S. Cl.** **417/63**; 364/188; 395/340

[58] **Field of Search** 417/2, 53, 63; 364/188; 702/81, 122; 128/904; 345/340, 348, 349, 350, 351

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Attorney, Agent, or Firm—Merchant & Gould P.C.

[57] **ABSTRACT**

The invention relates to systems and methods for communicating with ambulatory medical devices, such as drug delivery devices, both locally and remotely. In one embodiment, a caregiver drug pump communicates with a remote patient drug pump for data gathering, trouble shooting, and operational program changes. The caregiver drug pump is substantially identical in configuration to the patient drug pump. The caregiver drug pump transmits caregiver key input signals to the remote patient drug pump. The patient drug pump receives the key input signals, accesses a desired program, and transmits information for display on the display of the caregiver drug pump. In another embodiment, a computer is provided for communicating locally and/or remotely with a drug pump. The computer may include a display with an image of a pump. The computer may be operated through the use of a mouse or touch screen with respect to the image of the pump, to simulate use of the pump while using the personal computer. The computer may also be used as a training aid for training a caregiver and/or patient how to use the drug pump.

13 Claims, 10 Drawing Sheets

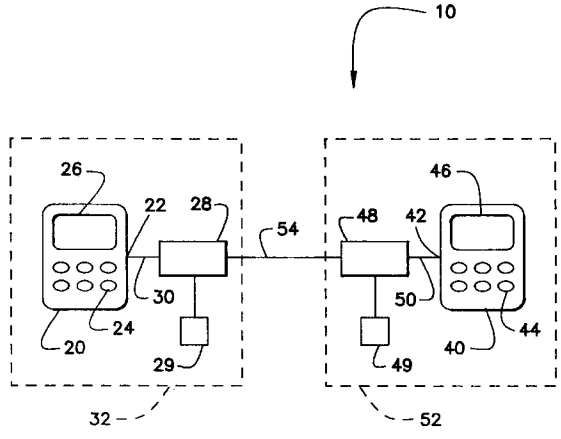

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FIG. 1

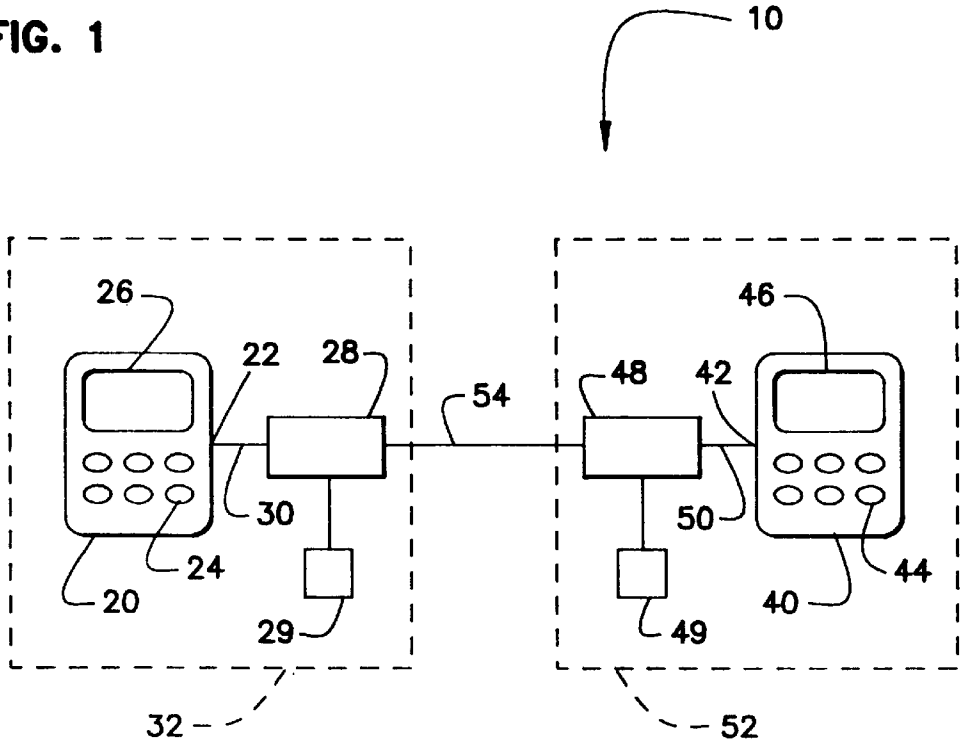
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FIG. 2

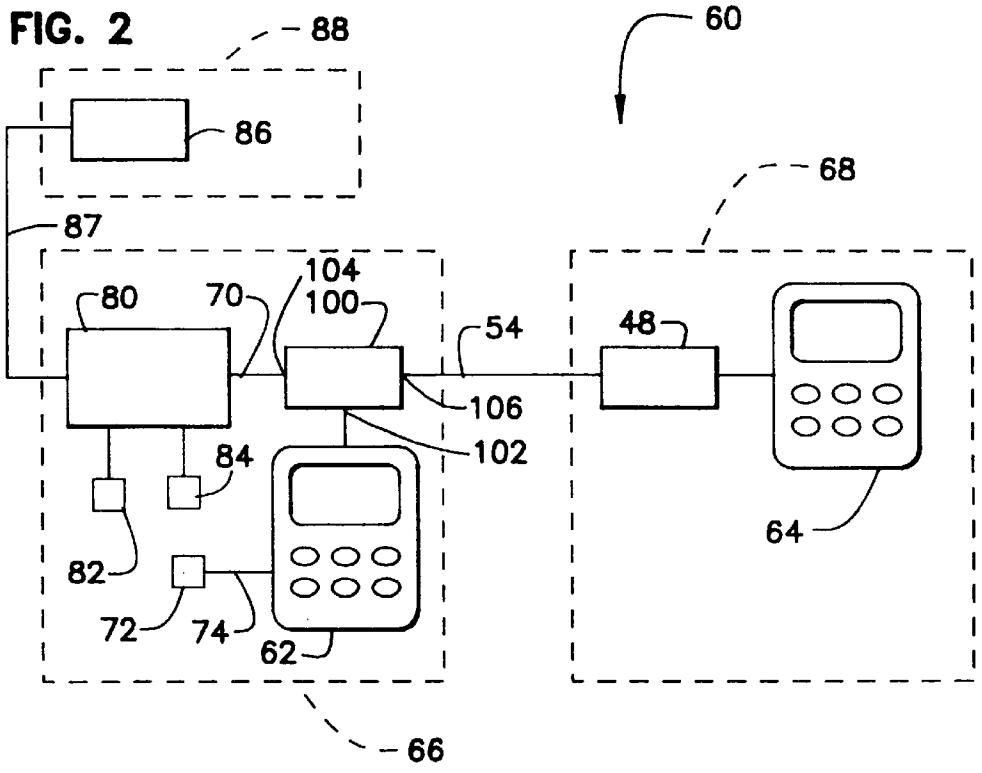
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FIG. 1A

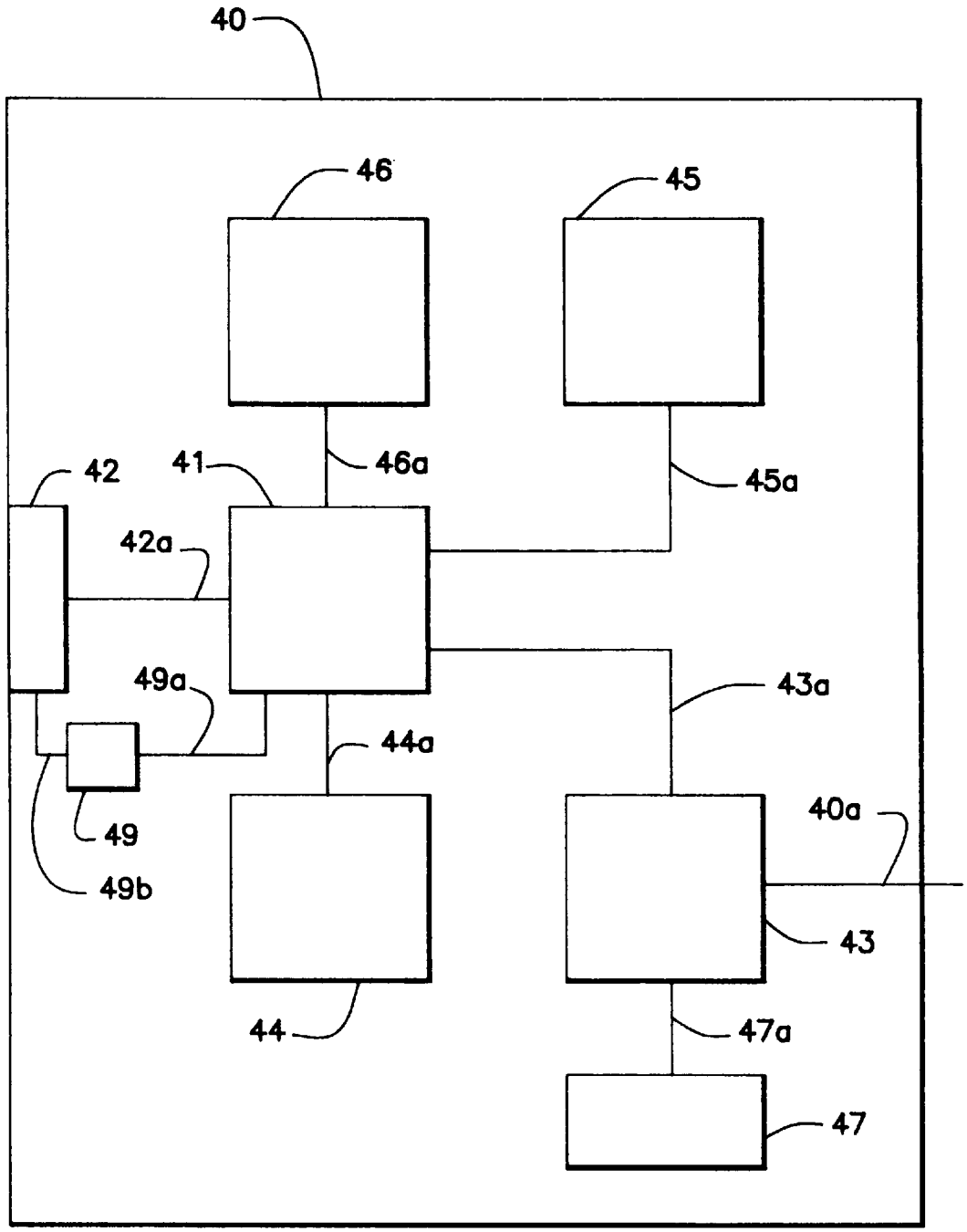
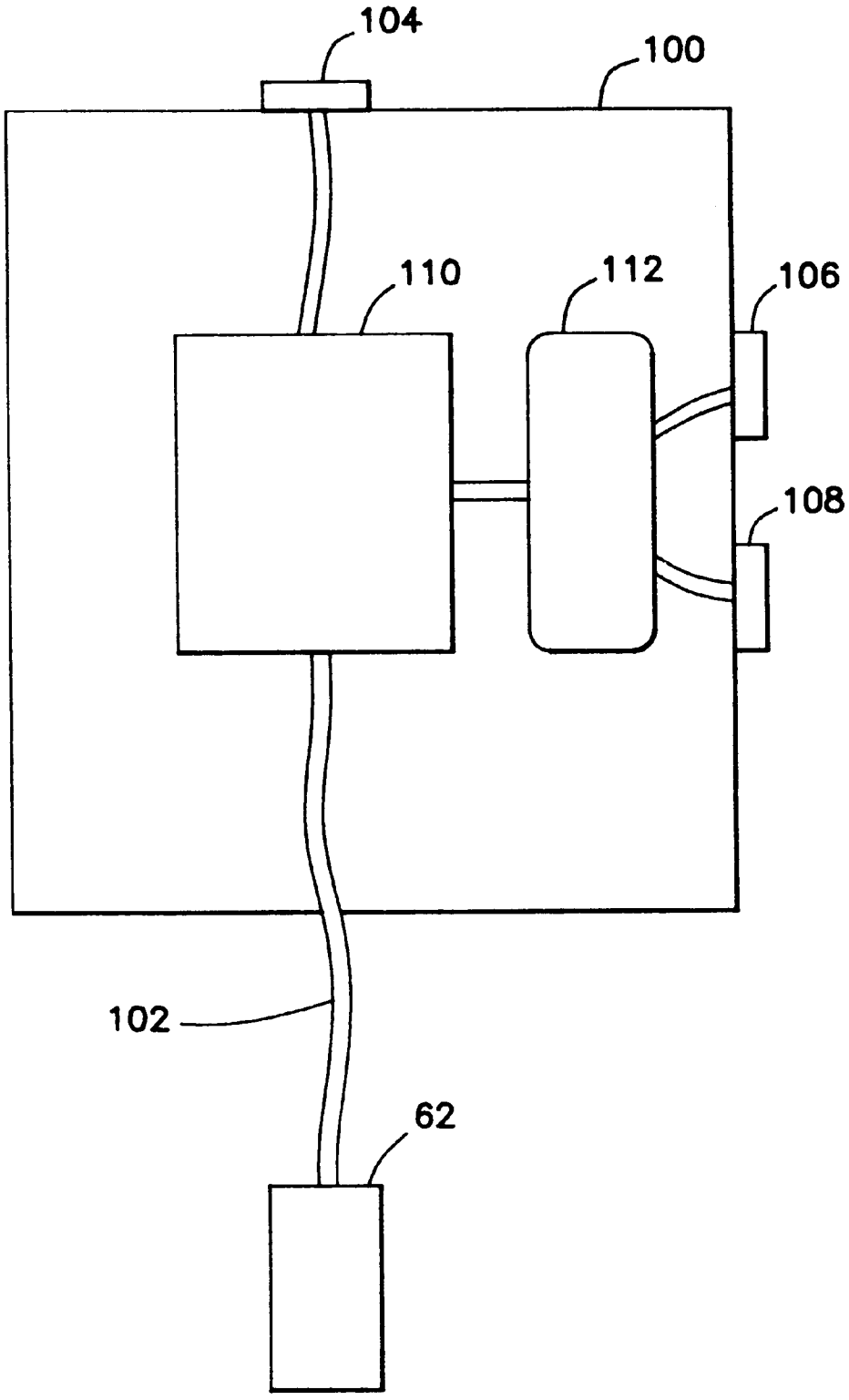


FIG. 3



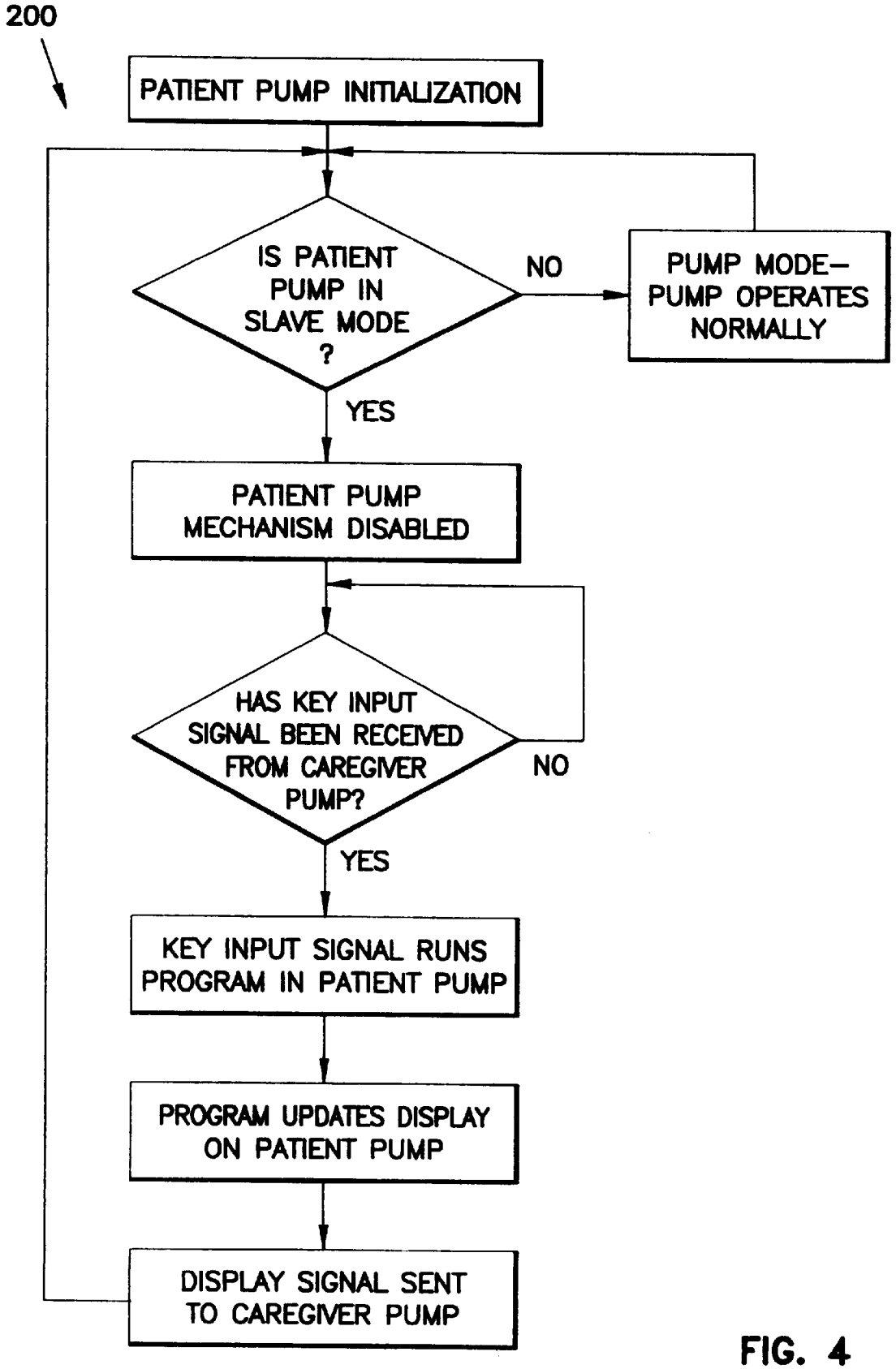

200
PATIENT PUMP INITIALIZATION
IS PATIENT PUMP IN SLAVE MODE ?
NO
PUMP MODE– PUMP OPERATES NORMALLY
YES
PATIENT PUMP MECHANISM DISABLED
HAS KEY INPUT SIGNAL BEEN RECEIVED FROM CAREGIVER PUMP?
NO
YES
KEY INPUT SIGNAL RUNS PROGRAM IN PATIENT PUMP
PROGRAM UPDATES DISPLAY ON PATIENT PUMP
DISPLAY SIGNAL SENT TO CAREGIVER PUMP

FIG. 4

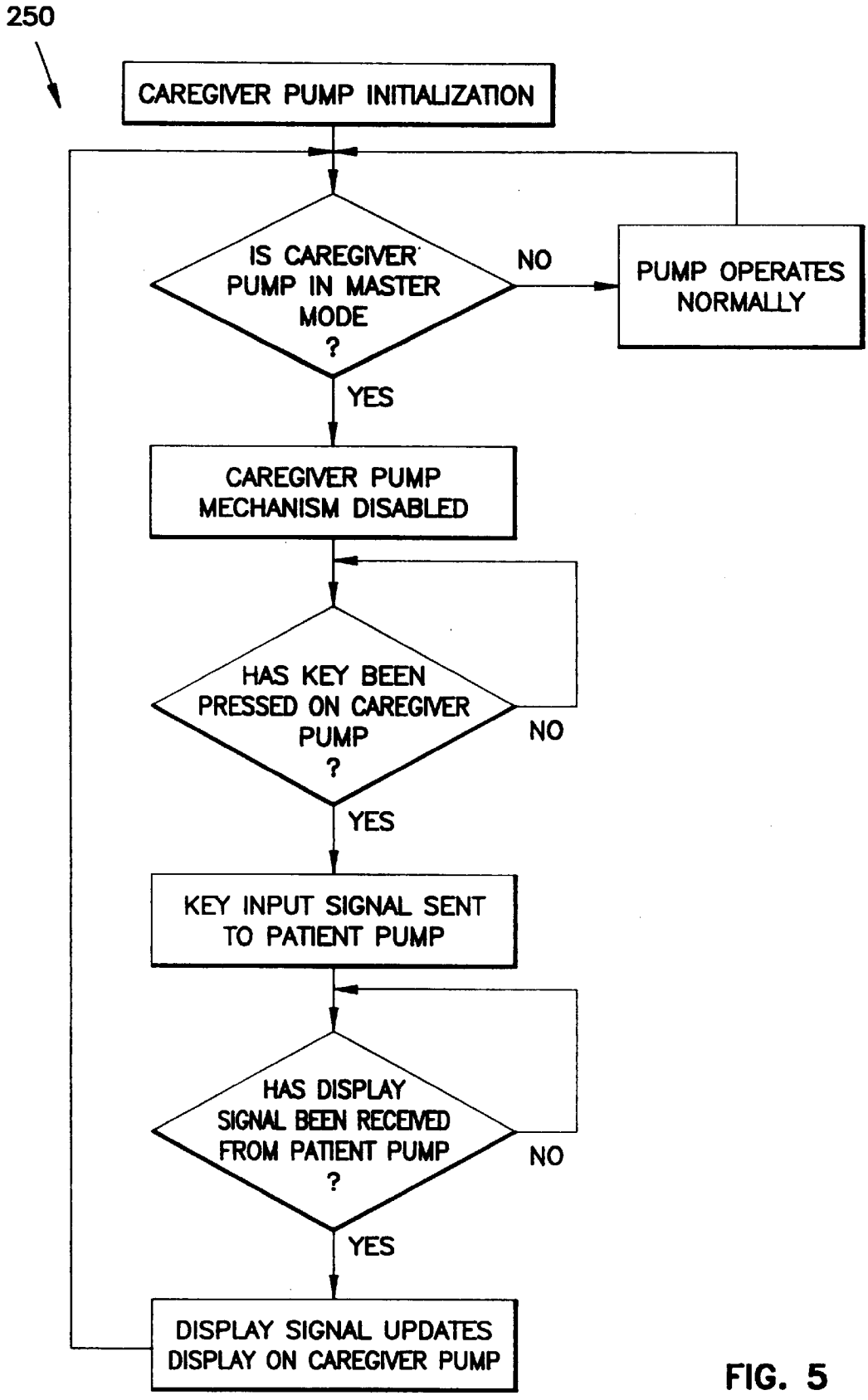

250
CAREGIVER PUMP INITIALIZATION
IS CAREGIVER PUMP IN MASTER MODE ?
NO
PUMP OPERATES NORMALLY
YES
CAREGIVER PUMP MECHANISM DISABLED
HAS KEY BEEN PRESSED ON CAREGIVER PUMP ?
NO
YES
KEY INPUT SIGNAL SENT TO PATIENT PUMP
HAS DISPLAY SIGNAL BEEN RECEIVED FROM PATIENT PUMP ?
NO
YES
DISPLAY SIGNAL UPDATES DISPLAY ON CAREGIVER PUMP

FIG. 5

300

302 CAREGIVER PUMP	304 PATIENT PUMP
CAREGIVER CONNECTS CAREGIVER MODEM CABLE TO CAREGIVER PUMP AND INSTRUCTS PATIENT TO CONNECT PATIENT MODEM CABLE TO PATIENT PUMP.	
PUMP TELLS MODEM TO TURN ON SPEAKER	PATIENT CONNECTS PATIENT MODEM CABLE TO PATIENT PUMP
CAREGIVER ASKS PATIENT TO VERIFY THAT PATIENT PUMP HAS RESPONDED WITH "PRESS ENTER TO START SLAVE COMMUNICATIONS" MESSAGE ON THE DISPLAY. CAREGIVER INSTRUCTS PATIENT TO PRESS ENTER KEY, THEN, WITHOUT HANGING UP THE PHONE, TO LISTEN FOR FURTHER INSTRUCTIONS, COMING FROM THE MODEM SPEAKER.	
	PATIENT PRESSES ENTER KEY
	PUMP TELLS MODEM TO START SLAVE COMMUNICATIONS. PUMP STARTS TWO MINUTE TIME OUT WHILE WAITING FOR CARRIER DETECT FROM MODEM.
	MODEM GOES OFF-HOOK
	MODEM DISCONNECTS PHONE
	MODEM TURNS ON SPEAKER
	MODEM SENDS SHORT BEEP TO CAREGIVER PUMP THEN LISTENS FOR CARRIER

FIG. 6A

300

302	304
CAREGIVER HEARS SHORT MODEM BEEP EITHER FROM PHONE HANDPIECE OR MODEM SPEAKER AND KNOWS THAT THE PATIENT PUMP IS READY	PATIENT SETS PHONE DOWN WITHOUT HANGING UP
CAREGIVER PRESSES ENTER KEY	
PUMP TELLS MODEM TO START MASTER COMMUNICATIONS, THEN PUMP WAITS FOR INCOMING DATA. PUMP STARTS TWO MINUTE TIME OUT WHILE WAITING FOR RESPONSE FROM PATIENT PUMP	
MODEM GOES OFF-HOOK	
MODEM DISCONNECTS PHONE	
MODEM SENDS CARRIER	
CAREGIVER SETS PHONE DOWN WITHOUT HANGING UP	MODEM RECEIVES CARRIER, THEN SENDS "CARRIER RECEIVED" SIGNAL TO PATIENT PUMP
	PUMP TELLS MODEM TO SHUT OFF SPEAKER
	MODEM SHUTS OFF SPEAKER
	PUMP SENDS "I'M HERE" SIGNAL TO CAREGIVER PUMP
PUMP ACKNOWLEDGES "I'M HERE" SIGNAL AND SENDS "OK TO BEGIN" SIGNAL TO PATIENT PUMP	
PUMP TELLS MODEM TO SHUT OFF SPEAKER	PATIENT PUMP RECEIVES "OKAY TO BEGIN" SIGNAL AND SENDS CURRENT DISPLAY SIGNAL TO CAREGIVER PUMP
MODEM SHUTS OFF SPEAKER	
PUMP SENDS KEY INPUT SIGNALS TO PATIENT PUMP	PUMP SENDS DISPLAY SIGNALS TO CAREGIVER PUMP IN RESPONSE TO KEY INPUT SIGNALS

FIG. 6B

400

402 CAREGIVER PUMP	404 PATIENT PUMP
CAREGIVER PRESSES STOP/START KEY	
PUMP SENDS "DISCONNECT" SIGNAL TO PATIENT PUMP	
PUMP SENDS "DISCONNECT" SIGNAL TO MODEM	PUMP ACKNOWLEDGES "DISCONNECT" SIGNAL
MODEM CUTS CARRIER	PUMP BEGINS TO BEEP
MODEM CONNECTS PHONE	PUMP SENDS "DISCONNECT" SIGNAL TO MODEM
MODEM TURNS ON SPEAKER	MODEM CUTS CARRIER
	MODEM CONNECTS PHONE
	MODEM TURNS ON SPEAKER
CAREGIVER UNPLUGS CAREGIVER MODEM CABLE	
MODEM DISCONNECTS SPEAKER	
MODEM GOES ON HOOK	
CAREGIVER PICKS UP PHONE THEN CALLS FOR PATIENT TO PICK UP PHONE.	
	PATIENT HEARS CAREGIVER IN MODEM SPEAKER AND PICKS UP PHONE
CAREGIVER TELLS PATIENT TO DISCONNECT PATIENT MODEM CABLE	
	PATIENT DISCONNECTS PATIENT MODEM CABLE
	PUMP STOPS BEEPING
	MODEM DISCONNECTS SPEAKER
	MODEM GOES ON HOOK
CAREGIVER RESUMES NORMAL VOICE COMMUNICATIONS	PATIENT RESUMES NORMAL VOICE COMMUNICATIONS

FIG. 7

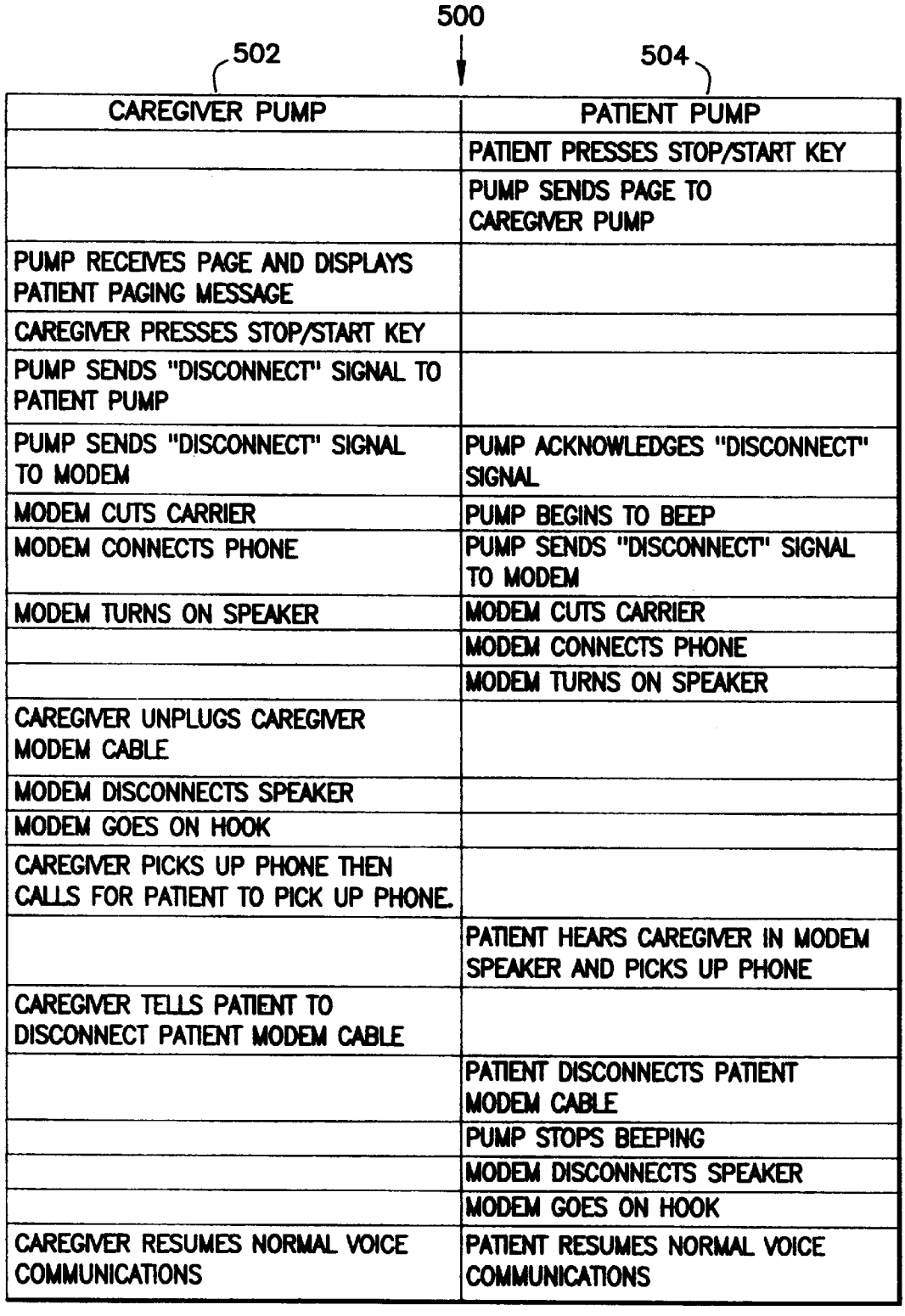

500
502
504
CAREGIVER PUMP
PATIENT PUMP
PATIENT PRESSES STOP/START KEY
PUMP SENDS PAGE TO CAREGIVER PUMP
PUMP RECEIVES PAGE AND DISPLAYS PATIENT PAGING MESSAGE
CAREGIVER PRESSES STOP/START KEY
PUMP SENDS "DISCONNECT" SIGNAL TO PATIENT PUMP
PUMP SENDS "DISCONNECT" SIGNAL TO MODEM
PUMP ACKNOWLEDGES "DISCONNECT" SIGNAL
MODEM CUTS CARRIER
PUMP BEGINS TO BEEP
MODEM CONNECTS PHONE
PUMP SENDS "DISCONNECT" SIGNAL TO MODEM
MODEM TURNS ON SPEAKER
MODEM CUTS CARRIER
MODEM CONNECTS PHONE
MODEM TURNS ON SPEAKER
CAREGIVER UNPLUGS CAREGIVER MODEM CABLE
MODEM DISCONNECTS SPEAKER
MODEM GOES ON HOOK
CAREGIVER PICKS UP PHONE THEN CALLS FOR PATIENT TO PICK UP PHONE.
PATIENT HEARS CAREGIVER IN MODEM SPEAKER AND PICKS UP PHONE
CAREGIVER TELLS PATIENT TO DISCONNECT PATIENT MODEM CABLE
PATIENT DISCONNECTS PATIENT MODEM CABLE
PUMP STOPS BEEPING
MODEM DISCONNECTS SPEAKER
MODEM GOES ON HOOK
CAREGIVER RESUMES NORMAL VOICE COMMUNICATIONS
PATIENT RESUMES NORMAL VOICE COMMUNICATIONS

FIG. 8

FIG. 9

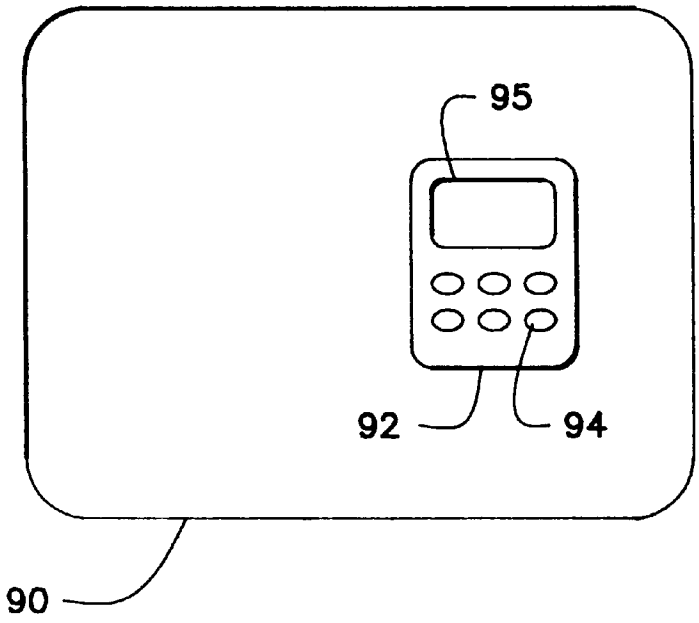
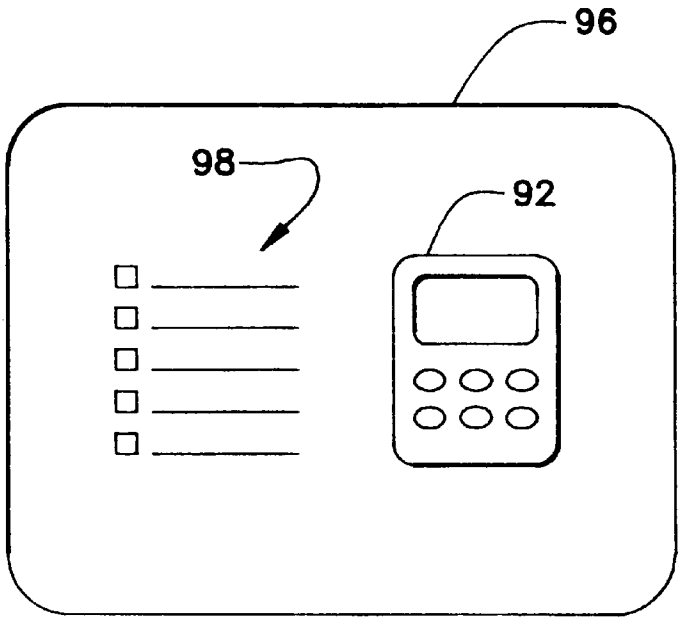


FIG. 10



SYSTEMS AND METHODS FOR COMMUNICATING WITH AMBULATORY MEDICAL DEVICES SUCH AS DRUG DELIVERY DEVICES

This is a Continuation of application Ser. No. 08/586,952, filed Jan. 16, 1996 now abandoned, which is a Continuation of patent application Ser. No. 08/276,025, filed Jul. 15, 1994, now issued as U.S. Pat. No. 5,485,408, which is a Continuation of patent application Ser. No. 07/942,288, filed Sep. 9, 1992, now issued as U.S. Pat. No. 5,338,157.

FIELD OF THE INVENTION

The present invention relates generally to ambulatory medical devices and methods for communicating with such devices. In particular, the present invention relates to systems and methods for locally and remotely communicating with drug delivery devices.

BACKGROUND OF THE INVENTION

Various ambulatory medical devices are known for treating and/or monitoring patients at a remote site away from the caregiver's or clinician's office. One example of an ambulatory medical device is a drug delivery device, such as a drug pump, for providing periodic or continuous drug delivery to the patient when the patient is away from the caregiver's office.

Certain drugs rarely achieve their maximum therapeutic action through conventional injection techniques. Many drugs reach their full potential only through precise delivery over an extended period of time. With controlled drug infusion through a drug pump, the drug can be given at a precise rate that will keep the drug concentration within the therapeutic margin and out of the toxic range. Ambulatory drug pumps can provide appropriate drug delivery to the patient at a controllable rate which does not require frequent medical attention and which allows the patient to leave the hospital or caregiver's office.

A failure to adequately monitor the drug pump and the patient's usage of the drug pump can reduce or eliminate any benefits the patient may have received from a proper drug delivery therapy. In some cases, the drug therapies can have serious health consequences to the patient if the drugs are not administered properly.

Several concerns arise when the patient utilizes the various ambulatory medical devices at remote sites. If the ambulatory medical device gathers data with respect to the device and/or the patient, the data needs to be easily accessible by the caregiver to permit the caregiver to monitor the device and the patient. Often, the patient may be of little or no assistance in accessing the data and communicating with the caregiver from the remote site. If the caregiver needs to physically handle the device to access the data, the device and caregiver must be brought to the same location.

Similar problems can also arise in that the medical devices may fail or be used improperly at the remote sites. If the device is not operating properly, the device may have to be brought to the caregiver, or the caregiver may have to visit the patient. If the caregiver attempts to trouble shoot from a remote site, the patient may be unable physically or mentally to sufficiently cooperate with the caregiver for the caregiver to trouble shoot from the remote site. Operating problems can arise at inconvenient times, such as at night or on weekends and holidays. The caregiver may also need to be able to easily periodically monitor the patient's usage of the medical device to observe patient compliance with prescribed treatments while the patient is at the remote site.

There may further arise a need for the caregiver to access the controller, such as the processor and the programs, which controls operation of the ambulatory medical devices. For example, in the case of drug delivery devices, some therapies change over time. The caregiver may need to access the operating program in order to change the operation of the drug delivery device. Further, some drug delivery devices, for example, may be used for very different applications, requiring different operating programs. These operating programs can be changed as the use of the drug delivery device changes. Resources may not be used efficiently if the caregiver and the device must be brought to the same location for the caregiver to access the processor and operating programs.

One specific situation often arises in the case of a drug pump where the caregiver needs to access the controller of the drug pump. The caregiver may visit the patient at the patient's home at some point after the drug therapy has begun using the drug pump. The caregiver may sample the patient's blood. The caregiver returns to the office and the blood sample is analyzed. The results of the blood analysis may indicate the patient is not receiving the proper drug therapy. This usually means the controller of the drug pump must be adjusted to give the proper therapy to the specific patient. To adjust the controller, the caregiver needs to be able access the controller.

Another problem facing caregivers in the area of ambulatory medical devices relates to the ease of remote communication with the devices, if such remote communication capability is provided. Remote communication with an ambulatory medical device using a personal computer or base station may be difficult for some caregivers, if the personal computer/base station operates differently than the medical device. The caregiver must then be knowledgeable both in operation of the medical device and in operation of the personal computer/base station. This concern also applies to local communication with the ambulatory medical device.

In the case of remote communication with a patient's medical device using a personal computer/base station, the caregiver also needs to remain near the personal computer/base station, or else transport the personal computer/base station with the caregiver, if the caregiver wishes to remain in communication with the patient's medical device.

It sometimes may become necessary to communicate with a personal computer or base station either locally or remotely in order to take advantage of the greater data handling or processing capability of the personal computer or base station, for example. The ability of the caregiver to communicate easily with the pump using a personal computer or base station may be important in those circumstances. In addition, the patient may be able to do very little to assist the caregiver in linking the remote medical device to the local personal computer/base station.

There is a need for systems and methods for communicating with ambulatory medical devices such as drug delivery devices, both locally and remotely, which addresses the above concerns and other concerns.

SUMMARY OF THE INVENTION

The present invention relates to systems and methods for communicating with an ambulatory medical device, such as a drug delivery device, and in particular, a drug pump. In one embodiment, a communication system is provided where a remote drug pump communicates with a similar local drug pump. Each of the drug pumps are provided with a pump

controller for controlling operation of the pump. The controller may include a processor and associated memory for storing operating programs and other information. The pumps each include a pumping mechanism controlled by the controller for pumping fluid to a patient in the normal pumping mode of operation.

Interconnect structure, such as modems, is provided to permit interconnection of the controllers of the pumps in the pump to pump communications mode of operation. The interconnect structure permits communication between the respective processors over a communications medium, such as conventional telephone communication lines. The telephone lines also permit initial voice communication between the patient and the caregiver using conventional telephones or other devices before the pumps are linked together for the pump to pump communications mode of operation. The modems may include speakers to facilitate ease of operation during pump to pump communication with patients who have difficulty in cooperating with the caregiver due to mental and/or physical limitations.

Each drug pump includes operator input structure for making operator inputs to the controller of the respective pump. The operator input structure is useful for selecting desired pump control programs or desired pump data or both from the memory of the processor of the pump. The information selection structure may include a keypad comprising a plurality of keys.

Display structure on each pump is interconnected to the controller of the respective pump. The display structure displays information about operations of the pump sent to the display structure by the controller. The display structure may display desired information from the memory of the processor, such as information relating to the normal pumping operations mode of the pumping mechanism. Other information that may be displayed may relate to various sensor outputs to the controller. Other information displayed may relate to the pump to pump communications mode. The display structure may include an LCD dot matrix display.

Information programmed into the controllers allows the two pumps to communicate in such a way during pump to pump communications that one pump controls the functions of the other. Information programmed into the local drug pump, or caregiver pump, instructs that the caregiver pump be put into the master mode at some point during operation. In the master mode, the local caregiver pump sends its keyboard inputs to a remote patient pump. The caregiver pump also receives its display inputs from the remote patient pump. The caregiver pump is used by the caregiver for such purposes as data gathering, trouble shooting, and operational program changes with respect to the remote patient pump. Ease of communication is provided since the caregiver is likely already familiar with operation of the patient pump, thereby saving training time because the caregiver pump operates similarly to the patient pump. Further, the caregiver can remain in constant communication with the patient pump by merely transporting the caregiver pump and a modem with the caregiver at all times.

The remote patient pump has information programmed into the controller that instructs the patient pump to be put into the slave mode at the appropriate time. In the slave mode, the patient pump receives its keyboard input signals primarily from the caregiver pump. The patient pump sends its display signals to the caregiver pump. In one embodiment, the slave mode of the patient pump disables the patient pump from actually pumping the fluid during communication with the caregiver pump.

In one embodiment, the caregiver pump and the patient pump both include program means for operating in both the master and slave modes. Automatic selection of the master or slave mode from the normal pumping mode is provided when a communications cable is connected to the respective pump.

Various program means and sequences are disclosed for communication between the local caregiver pump and the remote caregiver pump to facilitate efficient communication while emphasizing easy usage by the caregiver and by the patient, some of whom may have difficulty carrying out instructions from the caregiver over the telephone.

In another embodiment, systems and methods are provided for communicating between a remote pump and a local caregiver computer, such as a personal computer. Such communication may permit greater data processing utilizing the computer's data handling capability. Also, communication with the remote pump using the local computer may be useful for recertifying the remote pump periodically as is sometimes required with respect to medical devices. The local computer may also be useful in changing or adjusting the pump operations program of the remote pump. Modem communication structure permits communication over a communications medium, such as conventional telephone lines, between the remote pump and the local computer.

In a further embodiment, modem communication structure is provided which links a local pump to a local computer. Preferably, the modem communication structure also includes structure for further permitting communication between the local computer or the local pump and a remote pump. This modem communication structure permits: (1) local pump and local computer communication; (2) local pump and remote pump communication; and (3) remote pump and local computer communication.

In another embodiment of the invention, a computer system is provided, with a processor and memory, which is programmed to display an image of a pump on a display that resembles the pump utilized by the patient. The image includes representations of the keys and the display of an actual pump. The computer is further programmed such that the image of the pump is utilized to communicate with an actual remote pump or an actual local pump by manipulating or activating the keys on the image of the pump. The keys of the image can be activated by such techniques as through the use of a mouse or a touch screen. Activating the keys of the image of the pump simulates for the caregiver the presence of an actual pump. This facilitates reductions in training time for training the caregiver to communicate with the patient's pump, since the caregiver is most likely already familiar with operation of the patient's pump.

The computer system with the pump image program may also be used as a simulator for training the caregiver or the patient how to use the pump. The simulator includes various programs for simulating for the patient trainee and/or the caregiver trainee various pump operations situations with a patient's pump for pumping fluid. The simulator also includes various programs for simulating for the patient trainee and/or the caregiver trainee various communication situations with a patient's pump.

These and other features of the present invention are described in greater detail in the detailed description of the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, where like numerals refer to like features throughout the several views:

FIG. **1** is a schematic diagram illustrating a first system of local pump and remote pump communications.

FIG. **1A** is a schematic diagram illustrating components of the remote pump shown in FIG. **1**.

FIG. **2** is a schematic diagram illustrating a second system using a personal computer to communicate with a local pump and/or a remote pump. Local pump and remote pump communications capability is also shown.

FIG. **3** is a schematic diagram of a modem useful in the communication system shown in FIG. **2** to interconnect a personal computer, a local pump, and a remote pump.

FIG. **4** is a flow chart of an operational sequence of the patient pump with respect to the normal pumping mode for pumping fluid and the slave mode for pump to pump communication.

FIG. **5** is a flow chart of an operational sequence of the caregiver pump with respect to the normal pumping mode for pumping fluid and the master mode for pump to pump communication.

FIGS. **6**A and B comprise a single flow chart of operational sequences involving the caregiver pump and the patient pump during connection and communication between the caregiver pump and the patient pump when the patient pump is located at a remote site. FIG. **6**B follows after FIG. **6**A during operations.

FIG. **7** is a flow chart of operational sequences involving the caregiver pump and the patient pump when the caregiver wants to discontinue communication between the caregiver pump and the patient pump at some time during remote communication between the caregiver pump and the patient pump.

FIG. **8** is a flow chart of operational sequences involving the caregiver pump and the patient pump when the patient wishes to speak to the caregiver at some time during remote communication between the caregiver pump and the patient pump.

FIG. **9** is a schematic diagram showing a computer screen displaying an image of a pump, as part of a computer system used for communicating with a pump.

FIG. **10** is a schematic diagram showing a second computer screen displaying an image of a pump, as part of a computer system, and including information displayed on the screen relating to simulation sequences for use in training.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. **1**, a system **10** of communication between a local drug pump **20** (or caregiver pump) and a remote drug pump **40** (or patient pump) is shown. In system **10**, local pump **20** is functioning as a caregiver pump for use by the caregiver at the site **32** where the caregiver is located, such as the caregiver's office. Site **32** may be the caregiver's home, during on call periods, or even the caregiver's automobile, if the automobile is provided with some communications capability for sending and receiving signals with respect to another site. In system **10**, the caregiver operating pump **20** is typically a nurse, physician, therapist, or other medical personnel.

In system **10**, remote pump **40** is functioning as an ambulatory patient pump for pumping drugs to the patient and is located with the patient at a site remote from caregiver pump **20**, such as at the patient's home **52**. Also, site **52** may be the patient's workplace.

Pumps **20**,**40** each include a pumping mechanism which is capable of pumping fluid from a fluid reservoir to a patient. Specific components of patient pump **40** are shown in greater detail in FIG. **1**A. Caregiver pump **20** is preferably identical to patient pump **40** with respect to the features shown in FIG. **1**A.

Pump **40** as shown in FIG. **1**A includes a pumping mechanism **43** and a fluid reservoir **47** interconnected by a fluid communication structure **47***a*, such as a tube. The fluid reservoir **47** may be a cassette mounted to pump **40**, or the fluid reservoir may be a container located at a remote site from pump **40**, both interconnected to pump **40** with a fluid communication tube **47***a*. To pump fluid to a patient, the pump is also interconnected to the patient, such as through a tube **40***a*. The pumping mechanism **43** pumps fluid from the reservoir **47** to the patient through the tube **40***a* interconnected to the patient.

Pumps **20**,**40** may be any of a variety of drug delivery pumps. An example of one drug delivery pump is described in U.S. Pat. No. 4,559,038, incorporated herein by reference. In U.S. Pat. No. 4,559,038, a rotating camshaft is provided which engages two reciprocating valves and a reciprocating expulser. The valves and expulser engage a tube interconnected in fluid communication between a fluid reservoir and the patient. The rotating camshaft moves the valves and expulser to pump fluid through the tube.

In the communication system **10** of FIG. **1**, only patient pump **40** is utilized to pump fluid to the patient. Caregiver pump **20** is used by the caregiver to communicate with patient pump **40**. Caregiver pump **20** is preferably not used to pump fluid during pump to pump communication with patient pump **40**. However, caregiver pump **20** could be used to pump fluid to a patient before or after communication with patient pump **40**, should the need arise. In some cases, caregiver pump **20** could be used to pump fluid during pump to pump communications with patient pump **40**.

Pumps **20**,**40** each include a controller for controlling operation of the pumping mechanism utilized to pump fluid. Pump **40** shown in greater detail in FIG. **1**A includes a controller **41** interconnected to pumping mechanism **43** through connection structure **43***a*. The controller **41** preferably includes a processor and memory programmable with selected functions for controlling operation of the pumping mechanism **43**. As shown in FIG. **1**A, the controller **41** is also connectable to one or more electrical sensor elements in the pump, such as sensors **45**,**49**.

A variety of sensors like sensor **45** may be provided depending on the type of pump and the intended usage of the pump. For example, since the fluid is pumped through a tube **40***a* to the patient by the pump, the pump may include a downstream high pressure sensor to detect when an occlusion of the tube has occurred. A sensor may also be provided to sense when a vacuum develops in tube **47***a* upstream from the pump between the pump mechanism **43** and the fluid reservoir **47**, indicating a lack of fluid to be pumped. Other sensors may be provided to sense pump electrical power supply status. Still other sensors may be provided to monitor the operation of the mechanical components comprising the pumping mechanism. The sensors, like sensor **45**, all typically send a suitable electrical signal to the processor of controller **41** through connection structure, like structure **45***a*, indicative of the conditions sensed. The controller is appropriately programmed to receive and process the sensor signals it receives. Sensor **49** relates a particular sensor useful during pump to pump communications to assist the operators (both patient and caregiver) in communication between the pumps, which will be discussed in greater detail below.

The controller **41** includes memory for storing various programs and data related to operation of the pump. The processor runs the desired operating programs to control operation of the pumping mechanism **43**. The processor further responds to the sensor input signals by generating appropriate control output signals in accordance with its programmed control logic. Access to the processor is provided through an external communication port **42**. For caregiver pump **20**, access to the processor is provided through an external communication port **22** (see FIG. **1**).

Both caregiver pump **20** and patient pump **40** can be utilized for pumping or delivering a drug to a patient when the respective pump is interconnected to the patient. Pumps **20,40** are preferably identical with respect to the electrical and the mechanical fluid pumping functions. One advantage of this is that caregiver pump **20** can be an unused spare patient pump **40**. As will be discussed below, the respective controllers of pumps **20,40** may be programmed differently to operate in the appropriate desired manner during pump to pump communications. As will also be discussed, this programming can be done locally or remotely. Preferably, pumps **20,40** include appropriate programs to operate either as a master pump or as a slave pump during pump to pump communications. In some cases, the programs in each pump that control operation of the pumping mechanism will be different. This will also be discussed in more detail below.

One preferred processor that may be used in connection with pumps **20,40** is a MC68HCllE9 high-density complimentary metal-oxides semiconductor (HCMOS) high-performance microcontroller unit (MCU) by Motorola. Such processor includes **512** bytes of electrically erasable programmable ROM (EEPROM), and **512** bytes of RAM.

Pumps **20,40** each include operator input structure for permitting an operator of the respective pump to communicate with the controller of the pump, specifically the internal processor of the pump and the information in the internal memory. In one preferred embodiment, a plurality of operator keys **24** on caregiver pump **20** are provided for pressing by the caregiver. Preferably, each key has at least one function. Keys **24** send a signal to the controller of caregiver pump **20** indicative of the key pressed by the caregiver. The controller of pump **20** responds in the desired manner if an acceptable key press is made by the caregiver.

Patient pump **40** has keys **44** preferably identical to keys **24**. Keys **44** send a signal to the controller of patient pump **40** indicative of the key pressed. The controller of patient pump **40** responds in the desired manner if an acceptable key press is made by the patient. As shown in FIG. **1**A, keyboard **44** is interconnected to controller **41** through connection structure **44***a*.

Caregiver pump **20** includes a display **26** for displaying selected information stored in the controller. In one preferred embodiment, the display **26** includes an LCD dot matrix display. LCD dot matrix display **26** is interconnected to the controller of caregiver pump **20**. Display signals sent from the controller of caregiver pump **20** permit display of information related to operation of pump **20** on display **26**. One preferred LCD dot matrix display is a display with four lines and twenty-one characters per line.

Patient pump **40** has a display **46** preferably identical to display **26** of caregiver pump **20**. Display signals sent from the controller of patient pump **40** display information related to operation of pump **40** on display **46**. As shown in FIG. **1**A, display **46** is interconnected to controller **41** through connection structure **46***a*.

Communication port **22** of caregiver pump **20** permits interconnection of the controller of caregiver pump **20** to a modem **28** located locally with respect to caregiver pump **20**. Caregiver pump **20** is interconnected to modem **28** through connection structure **30**, such as an RS232 serial cable. Caregiver pump **20** and modem **28** may be located at the caregiver's office **32**, at the caregiver's home during on-call periods, or even at a mobile site, such as the caregiver's automobile.

Communication port **42** permits interconnection of the controller of patient pump **40** to modem **48** with connection structure **50**, such as an RS232 serial cable. Patient pump **40** and modem **48** are both located remotely to caregiver pump **20** and modem **28**, such as at the patient's home or workplace **52**, or other location remote from caregiver pump **20**.

Communication between pump **20** and pump **40** through modems **28,48** is over communications medium **54** such as conventional telephone lines, cellular phones, fiber optics links, satellite links, microwave links, or other. Modems **28,48** preferably communicate at 9600 bps and include error correction and data compression features over conventional telephone lines.

One advantage of the present invention is that the caregiver can communicate with the patient pump **40** using a similar pump, the caregiver's pump **20**. The caregiver presumably has knowledge of operation of patient pump **40**. This knowledge is useful in utilizing caregiver pump **20** to communicate with patient pump **40** to access the processor of patient pump **40** from a remote location.

Communication between the controller of the remote patient pump **40** and the controller of the local caregiver pump **20** permits remote data gathering from the remote patient pump by the local caregiver pump. Such data gathering may be useful for periodic monitoring of the patient pump **40** during use of the patient pump at the remote site. Data gathering may also be useful at the end of the patient use.

Communication between the remote patient pump **40** and the local caregiver pump **20** permits troubleshooting with respect to the remote patient pump, without the caregiver being located at the same location as the patient's pump. Remote troubleshooting is useful in the case where patients are unfamiliar with the some of the more sophisticated operations of their pump. Also, remote troubleshooting using the pump to pump communication system is useful for patients who have difficulty orally communicating with the caregiver over the telephone.

Communication with the remote patient pump **40** is also useful for accessing the pump operations programs for changing or adjusting the operation of the remote patient pump from the local site, thereby saving the caregiver and the patient time from not having to make an in-person visit.

Information programmed into the controller of the caregiver pump **20** permits the caregiver pump **20** to be put into a master mode from the normal pumping mode at the appropriate time. In the master mode, caregiver pump **20** sends a keyboard input signal indicative of a key **24** pressed by the caregiver over port **22** to patient pump **40**. In the master mode, caregiver pump **20** receives its display signals primarily from patient pump **40** via communication port **22**. In the master mode, the key presses on keys **24** of caregiver pump **20** do not access the memory of caregiver pump **20** for the purposes of programming the memory of caregiver pump **20** or selecting information for display relating to caregiver pump **20**. The master mode is primarily for permitting caregiver pump **20** to communicate with the controller of patient pump **40** for the purposes of programming the memory of patient pump **40** or selecting informa-

tion for display relating to patient pump **40** from the memory of patient pump **40**.

With respect to patient pump **40**, information programmed into its controller permits patient pump **40** be put into a slave mode from the normal pumping mode at the appropriate time. In the slave mode, patient pump **40** receives keyboard input signals primarily from caregiver pump **20** via communication port **42**. Patient pump **40** sends its display signals from communication port **42** to caregiver pump **20**.

To communicate between caregiver pump **20** and patient pump **40** over modems **28,48**, caregiver pump **20** is out of the normal pumping mode and in the master mode. Similarly, patient pump **40** is out of the normal pumping mode and in the slave mode. In some cases, controllers with sufficient capacity may be provided where the pumps **20,40** operate simultaneously in the normal pumping mode and in the master or slave modes.

In system **10**, patient pump **40** is at least programmed to be operable in two modes, the normal pumping mode and the slave mode. There typically is not a need for patient pump **40** to operate in the master mode when the patient possesses the patient pump. Further, in system **10**, caregiver pump **20** is at least operable in the master mode. However, situations are anticipated where it is desireable to have one or both pumps **20,40** include programs for operation in the normal pumping mode, the slave mode, and the master mode. In some cases, caregiver pump **20** may be an unused patient spare. At a later date, the unused patient spare may be needed as a patient pump. This would require the slave mode operating program, and a particular normal operation mode program suitable for the patient. It may be more efficient for the caregiver if the controller of each pump **20,40** is preprogrammed to include both the master mode program and the slave mode program. The selection of master or slave mode may be made by the caregiver by preconfiguring the patient's pump **40** to enter the slave mode during pump to pump communication, and not enter the master mode. The caregiver would have the capability to preconfigure the caregiver pump **20** to only enter the master mode during pump to pump communication, and not the slave mode if the caregiver desired . At some point later in time, the caregiver could reconfigure the caregiver pump **20** to only enter the slave mode during pump to pump communications if the caregiver pump **20** was needed as a patient pump.

In system **10** of FIG. **1** which shows linking caregiver pump **20** to patient pump **40**, the caregiver is able to access the controller of patient pump **40**, make various inputs using the caregiver's pump **20**, and receive back display inputs from patient pump **40** such that the caregiver can see the display inputs on the display **26** of caregiver pump **20**. Such communication can occur when the patient pump **40** is located at a remote site from caregiver pump **20**. This is particularly advantageous in saving resources by reducing the number of in-person visits between the caregiver and the patient.

In one embodiment, disabling structure is provided with respect to caregiver pump **20** for disabling the pumping mechanism of caregiver pump **20** such that during pump to pump communications, the pumping mechanism is disabled. similarly, for patient pump **40**, disabling structure is provided to disable the pumping mechanism of patient pump **40** during pump to pump communications. This may be necessary due to processor capability limitations. This may also be a safety feature to prevent a caregiver from starting operation of the patient's pump from the remote site. However, in some situations it may be desirable for caregiver pump **20** to begin operation of the pumping mechanism of patient pump **40** at a site remote from the location of the caregiver during pump to pump communications. If a suitable controller is provided, it may be possible to operate the pumping mechanism of patient pump **40** while patient pump **40** is communicating with caregiver pump **20**.

Referring now to FIG. **4**, a flow chart **200** is shown illustrating one preferred operational sequence of patient pump **40** with respect to the normal pumping mode and the slave mode. FIG. **5** is a flow chart **250** illustrating one preferred operational sequence of caregiver pump **20** with respect to the normal pumping mode and the master mode. FIGS. **4** and **5** illustrate the operational sequences for each pump with respect to normal pumping operations mode, or pump to pump communications operations mode (slave and master modes). FIGS. **4** and **5** specifically show the sequences with respect to communicating the key input signals and the display signals between the pumps.

Referring now to FIGS. **6**A and **6**B, a flow chart **300** is shown for more specific operational sequences followed during connection and communication between caregiver pump **20** and patient pump **40**, respectively. Flow chart **300** of FIGS. **6**A and **6**B includes a caregiver sequence **302** in the left hand column and a patient sequence **304** in the right hand column. Flow chart **300** also includes actions to be taken by the patient and the caregiver during connection and communication between the two pumps.

The flow chart **300** of FIGS. **6**A and **6**B shows various steps including the step of hitting the ENTER key. The ENTER key is one key of keys **24** on caregiver pump **20** and keys **44** on patient pump **40**.

If a caregiver wanted to monitor or program a patient's pump **40** over the phone line **54**, the caregiver and the patient would first contact each other, such as by voice communication over the telephone **29,49**, as shown in FIG. **1**, to begin initiation of pump to pump communication. Telephones **29,49** may be conventional telephones including means for dialing another phone, and a handpiece or other device for permitting voice communication with the party on the other end. Prior to initiation of pump to pump communication, both pumps **20,40** are in the normal pumping mode. At the top of each column **302,304** of FIG. **6**A, pumps **20,40** are in the normal pumping mode. As shown in FIG. **6**A, the caregiver would first instruct the patient to connect pump **40** to modem **48**, thereby automatically stopping the pump and selecting the appropriate processor program for the slave mode.

Automatic selection of the slave mode and stoppage of the normal pumping mode in patient pump **40** is provided using suitable logic circuitry and sensor structure, such as sensor **49** in FIG. **1**A, to sense the presence of cable **50**. Automatic selection of the slave mode and stoppage of normal pumping mode by inserting cable **50** into patient pump **40** is useful since it eliminates one or more keyboard entries that might otherwise be necessary by the patient or caregiver to place patient pump **40** in the slave mode from the normal pumping mode. Alternatively, the patient may have to hit a predetermined key **44** or flip a suitable switch to exit the normal pumping mode and enter the slave mode if no automatic selection of the slave mode and automatic stoppage of the normal pumping mode is provided.

In FIG. **1**A, sensor **49** is interconnected to communications port **42** through connection structure **49***b*, and to controller **41** through connection structure **49***a*. Sensor **49**

may include two spaced apart pins which engage the communication cable **50** to close an electrical loop when the cable **50** is operatively positioned in communications port **42**. Closure of the loop sends a suitable signal to controller **41** that the cable **50** is present and pump to pump communications is desired, i.e. the slave mode operations program.

The operating system of caregiver pump **20** shall allow the pump to be placed in the caregiver mode of remote programming from the normal pumping mode of operation. Automatic selection of the master mode and automatic stoppage of the normal pumping mode in caregiver pump **20** is provided using suitable logic circuitry and sensor structure to sense the presence of cable **30**, such as with a similar sensor to sensor **49** of patient pump **40**. Alternatively, the caregiver may have to hit a predetermined key **24** or flip a suitable switch to exit the normal pumping mode and enter the master mode if no automatic selection linked to insertion of cable **30** is provided.

Caregiver pump **20** operating in the master mode includes program means for initiating a modem link to the patient pump **40** operating in the slave mode, as shown in flow chart **300** of FIGS. **6**A and **6**B. The phone connection to the patient pump **40** shall be assumed to be open. When the modem link between the pumps is established, each time the caregiver presses a key **26** on caregiver pump **20**, a key input signal is sent by program means in the controller of caregiver pump **20** to patient pump **40**. Program means in patient pump **40** responds to the signal as if it were a key pressed on its own keyboard. Once the processor of patient pump **40** responds to the key input signal, program means in the controller of patient pump **40** sends the updated display signal to caregiver pump **20**.

As shown in FIG. **6**B, patient pump **40** sends its current display to caregiver pump **20** once the pumps are first linked together. In pump to pump communications, the controllers are preferably menu driven and the current display lets the caregiver see the current status of the patient pump **40** before the caregiver begins to send key input signals to patient pump **40** to obtain the desired information from the patient pump. Following the display on display **26** of the current information on display **46**, caregiver pump **20** receives its displays sent to caregiver pump **20** in response to the key inputs to caregiver pump **20** which are sent to patient pump **40**.

Instead of an automatic initiation of the modem link to patient pump **40** operating in the slave mode, the caregiver and the patient could both hang up their respective phones after the modem cables were connected. Patient pump **40** is programmed to instruct modem **48** installed at the patient's home to answer the phone the next time it rings. The patient would then wait for the caregiver to call back. Caregiver pump **20** is programmed to instruct modem **28** to call the patient back. Once modem **28** is connected with modem **48**, communication between the respective controllers is provided with respect to key input signals and display signals.

In one embodiment, display **46** of patient pump **40** displays everything that is sent to display **26** of caregiver pump **20**. In another embodiment, the controller of patient pump **40** is programmed to include a blocking program to block some or all of the information that is sent to the controller of caregiver pump **20** from the controller of patient pump **40** from being displayed on display **46** of patient pump **40** during pump to pump communication. This may be advantageous in keeping some information from the patient, such as controller access codes used to access the processor of patient pump **40** via the keys **44**, or keys **24** during pump to pump communications.

If the communication session were interrupted by a bad phone line, patient pump **40** might remain unchanged or partially programmed. During programming of patient pump **40**, caregiver pump **20** could get a continuously updated status report from patient pump **40** through appropriate programming in caregiver pump **20** and patient pump **40**. The caregiver could review the status report after disconnecting the pump from the modem to verify that patient pump **40** had been programmed as desired by the caregiver.

The controller of each pump **20,40** controls operation of the respective modem **28,48** attached as a peripheral device. The controller of each pump **20,40** instructs its respective modem to go off-hook and disconnect the phone at the initiation of pump to pump communications. The controllers further control operation of a modem speaker associated with each modem so that the patient and caregiver can orally communicate before pump to pump communication begins, and after the voice transmitting and receiving characteristics of one or both of the telephone hand piece have been terminated. The modem speakers are useful if the patient or caregiver is not using the telephone handpiece and such communication is desired. The one party can call to the other through the speaker to pick up the telephone handpiece. Also, the modem speaker lets the caregiver hear predetermined signals from the patient pump **40** during connection to let the caregiver know when the patient pump **40** is ready to begin pump to pump communication, as shown in the flow chart of FIGS. **6**A and **6**B.

The controller of each pump **20,40** may be provided with masking programs to mask the keys **24,44** which are inactive during pump to pump communication.

Referring now to FIG. **7**, a flow chart **400** of a caregiver initiated disconnect operational sequence is shown for disconnecting caregiver pump **20** from patient pump **40**. Such disconnect operational sequence is desirable when the caregiver no longer desires communication with patient pump **40**. In the flow chart **400** of FIG. **7**, a caregiver sequence **402** is shown in the left hand column and a patient sequence **404** is shown in the right hand column. Flow chart **400** describes the various steps during the disconnect sequence initiated by the caregiver. At the top of each column **402,404** of FIG. **7**, pumps **20,40** are in the master and the slave modes, respectively.

Attempting to start the caregiver pump **20** is one method of signalling to the controller to terminate the pump to pump communication. The controller of caregiver pump **20** begins the disconnection sequence with respect to modem **28**. The controller of caregiver pump **20** further requests that patient pump **40** begin the disconnection sequence with respect to modem **48**.

The operating system of each controller allows for automatic disconnection of the respective modems at the conclusion of pump to pump communication, as shown in FIG. **7**. The controllers further control operation of the modem speaker so that the patient and the caregiver can orally communicate after pump to pump communication, such that the caregiver can instruct the patient during the disconnect procedures prior to telephone voice communication through the telephone handpiece of the patient.

Program means is provided with patient pump **40** to control operation of a beeper, other sound alarm, or other pump to patient indicator to inform the patient of the upcoming disconnection, as noted in flow chart **400** of FIG. **7**. The beeping or other signal may continue until the disconnection is complete. This is useful in informing the patient when the pump to pump communications discon-

nection procedure begins and when it ends such that the pump is ready to be used in the normal pumping mode.

Referring now to FIG. **8**, a flow chart **500** for a patient initiated disconnect operational sequence is shown. The flow chart of FIG. **8** shows a caregiver sequence **502** in the left hand column and a patient sequence **504** in the right hand column. At the top of each column **502,504** of FIG. **8**, pumps **20,40** are in the master and slave modes, respectively.

In the flow charts of FIG. **7** and **8**, it is noted that the caregiver and the patient press the STOP/START key. The STOP/START key is another one of the keys on keys **24,44** of pumps **20,40**. If the pumps are not in the normal pumping mode during pump to pump communication, as is the case in one embodiment, then the STOP/START key is a convenient means for sending a signal to the respective controllers that a discontinuation of the pump to pump communications session is desired by the patient or the caregiver.

As shown in FIG. **8**, attempting to start patient pump **40** using the STOP/START key on patient pump **40** is a one method of signalling to the processor to terminate the pump to pump communication. Patient pump **40** requests that caregiver pump **20** begin the disconnection sequences. Patient pump **40** waits for caregiver pump **20** to initiate the disconnect process. The controller of caregiver pump **20** begins disconnection with modem **28**, and the controller of caregiver pump **20** further requests that controller of patient pump **40** begin the disconnection sequence with respect to modem **48**. It is to be appreciated that when patient pump **40** receives a key input signal from the patient to begin disconnection of the pump to pump communications connection, caregiver pump **40** may continue until caregiver desires to terminate the pump to pump communications connection. The caregiver presses a key, such as the STOP/START key, as noted in FIG. **8** to begin the disconnection sequence at the desired time.

As in the caregiver disconnect sequence of FIG. **7**, the disconnect sequence of FIG. **8** includes the controllers controlling operation of the modem speakers so that the patient and the caregiver can orally communicate after pump to pump communication, so that the caregiver can instruct the patient during the disconnect procedures prior to telephone voice communication through the handpieces.

Program means is provided with patient pump **40** to control operation of a beeper or other sound alarm or patient indicator to inform the patient of that the disconnection requested by the patient is upcoming, as noted in flow chart **500** of FIG. **8**. The beeping or other signal continues until the disconnection is complete. The audible or other patient signal may be used in combination with or in alternative to the use of the modem speaker at the patient site to indicate to the patient when the cable **50** is to be disconnected from patient pump **40**.

Program means is provided with caregiver pump **20** to control operation of a beeper or other sound alarm or caregiver indicator to inform the caregiver that the disconnection has been requested by the patient. This is a page type function where the caregiver can continue with pump to pump communication, or start the disconnect sequence by pressing the STOP/START key.

In some applications, the controller of patient pump **40** is locked, at least partially, via an access code program to prevent the patient from altering the pump operations program or from accessing other information in the memory. In one preferred embodiment, the caregiver can unlock the pump lock of patient pump **40** from a remote location via the pump to pump communication system. Preferably, the caregiver can then relock the pump lock of patient pump **40** after the caregiver has adjusted or changed the pump operations program. Automatic relock program means may be provided to automatically relock the controller at the conclusion of the caregiver's access of the controller to change the operating programs.

Referring now to FIG. **2** where an alternative embodiment is shown, the schematic diagram illustrates a communication system **60** for communication between pump **62** and a computer **80**, both located at caregiver's office **66**. Pump **62** may be a caregiver pump, like caregiver pump **20**, or a patient pump, like patient pump **40**.

FIG. **2** also illustrates communication between a patient pump **64**, located at the patient's home **68**, and both computer **80** and pump **62**. It is to be appreciated that in some applications, pump **62** may not be present. Also, it is to be appreciated that in some applications pump **64** may not be present. In either of those applications, computer **80** would be communicating only with the remaining pump.

An example of computer **80** includes an 80386 INTEL microprocessor, with 2 megabytes of RAM and operated by commercially available operations software such as DOS, UNIX, and others and further programmed with application specific program functions to communicate with pumps **62,64** and carry out the specified tasks desired by the caregiver. A suitable keyboard may be provided with computer **80** to make operator inputs to the microprocessor.

As shown in FIG. **2**, computer **80** may further communicate with a second computer **86** to transfer data and or programs to and from computer **80** over communications medium **87**, such as conventional telephone lines. For example, computer **80** may be located at the caregiver's office **66**, such as a hospital. The second computer **86** may be located at the pump manufacturer's/servicer's facilities **88**. The second computer may receive and transmit information to a plurality of computers **80**. This arrangement may be useful for maintaining a plurality of patient pumps **64**, through a plurality of caregiver's offices **66**. Also, improved drug therapies may result if the pump manufacturer/servicer has ready access to patient pump usage data.

Pumps **62,64** are preferably identical mechanically and electrically to pumps **20,40** described previously. In some situations, the controllers of pumps **62,64** may be programmed differently, depending on how the pumps are to be used. Pump **64** is typically used as a patient pump. As a patient pump, pump **64** requires the normal pumping mode operating program and the slave mode operating program at minimum.

In system **60**, pump **62** may be a patient pump or a caregiver pump. As a patient pump, pump **62** requires the normal pumping mode operating program and the slave mode operating program at a minimum. Pump **62** as a patient pump is present at the same site as computer **80** such as when pump **62** is brought in by the patient. In some situations, pump **62** may be a patient pump that is in the caregiver's office **66** for data gathering, trouble shooting, and/or program changes or modifications. Also, before the patient leaves the caregiver's office **66**, pump **62** is present in caregiver's office **66** for use as a patient pump in the caregiver's office. As a caregiver pump, pump **62** requires the master mode operating program at a minimum. Pump **62** operating as a caregiver pump may also include the normal pumping mode operating program and the slave mode operating program.

To permit communication between pump **62**, computer **80**, and pump **64**, a modem **100** is provided. Referring now

to FIG. **3**, modem **100** is shown in additional detail. Modem **100** includes a local pump communications cable **102** for electrical connection of modem **100** to a local pump such as pump **62** shown in FIG. **2**. Cable **102** is like cables **30,50** of FIG. **1**. Cable **102** extends from modem controller **110** for selective connection to pump **62**.

Modem **100** further includes a computer communications port **104** for electrically linking modem **100** with computer **80** as shown in FIG. **2**.

Modem **100** further includes a phone system communications port **106** for electrically linking modem **100** to remote sites over communications medium **54**. In the embodiment shown, communications port **106** permits interconnection of modem **100** with modem **48** over the telephone lines **54**, as shown in FIG. **2**. Such interconnection permits communication between modem **100** and patient pump **64**, located at a remote site from modem **100**.

Modem **100** further includes a local phone communications port **108** to permit interconnection of a local phone (not shown) with modem **100**. Local phone port **108** permits use of a local phone such that the caregiver can communicate by conventional telephone voice communication with the patient, before a modem link is established and after the modem link is terminated.

Modem **100** permits information to be transmitted from computer **80** to a remote site over the phone lines **54**. Modem **100** further permits pump **62** to communicate with the remote site over phone lines **54**. Remote communication with pump **64** over the phone lines through modem controller **110** and modem module **112** is preferably at 9600 bps (bits per second). Modem **100** preferably includes error correction and data compression capabilities.

Modem **100** further permits communication between pump **62** and computer **80**. Preferably, such communication is at 19,200 bps through the modem controller **110** in a pass through configuration. Pump **62** is preferably not linked directly to computer **80**, since pump **62** may be provided with different power supplies other than conventional **110** volt power supplies used to power computer **80**. Also, it is desireable to electrically isolate pump **62** from computer **80** to protect pump **62** and the patient from hazards of the electrical source powering computer **80**, such as electrical shock. Preferably, modem **100** communicates with computer **80** through appropriate connection structure, such as an RS232 serial cable.

FIG. **2** also shows pump **62** interconnected to its own stand alone printer **72** interconnected with connection structure **74**, such as an RS232 serial cable. Parallel communication may be used, instead of serial communication. Printer **72** produces a hard copy of information stored in the controller of pump **62**. In some cases, printer **72** would be useable only through the communications port which connects pump **62** to modem **100**, as shown in FIG. **2**. In other words, pump **62** may not be useable simultaneously with printer **74** and modem **100**. An appropriately sized controller and two communications ports would permit such usage.

Communication between computer **80** and a pump, whether remotely (with pump **64**) or locally (with pump **62**) is useful for several reasons. First, computer **80** may be provided with greater memory and data processing capabilities than exist with the individual pumps **62,64**. Printing capabilities may be greater with a printer **82** electrically interconnected to computer **80**. Display capabilities may be greater with a monitor **84** electrically interconnected to computer **80**. Also, computer **80** may be useful in the recertifying operations of the pumps periodically, as required to verify operability and accuracy of the pumps.

Computer **80** also may be useful for making program adjustments or application changes in the pumps **62,64**. For example, drug delivery devices may be used in a variety of normal pumping modes, or applications, such as 1) pain control; 2) nutrition; 3) chemotherapy; and 4) antibiotic therapy. Other applications are possible.

Each of the applications may involve different operations of the pumping mechanism. Each application may have one or more patient specific variations on operation of the pumping mechanism and other pump control functions. Also, some of the applications may involve some patient input, such as is sometimes the case in pain control applications. For example, if the patient is experiencing pain at a particular time, the caregiver may provide for increased dosages as needed by the patient, within specified parameters such as time and amount. In this application, the pumping mechanism needs to be operable automatically, and at the discretion of the patient, within the specified parameters. The operating program contains the appropriate pump control commands for controlling the pumping mechanism and the functions of the keys which permit patient control of the pumping mechanism. The other applications may include different pump control commands and different functions of the keys. Within each of the four applications listed above, various different pump operations programs may exist. The controller of the patient pump **40** may be appropriately programmed by the caregiver for the specific patient usage.

It is to be appreciated that the caregiver pump **20** and the patient pump **40** do not need to include the same application program for operating the pumping mechanism. A significant advantage of the present invention is that the caregiver can communicate successively with different patients, with each patient involving a different pump application, or each patient involving the same pump application with different patient specific functions. At a minimum, it is preferred that caregiver pump **20** includes the master mode operations program, and that patient pump **40** includes the slave mode operations program and one application or normal pumping mode operations program for operating the pumping mechanism to pump fluid to the patient. Preferably, it is more convenient for the caregiver if caregiver pump **20** and patient pump **40** include both the slave mode operations program and the master mode operations program, and also at least one normal pumping mode operations program.

It is anticipated that the caregiver can locally or remotely program the controllers of pumps **20,40,62,64** such that the pump operates either in 1) the normal pumping mode or slave mode, or 2) the normal pumping mode or the master mode at the initiation of the pump to pump communications sequences.

Various pump related data may be stored in the controllers of pumps **20,40**. Information which may be gathered during use of patient pump **40** includes date and time of:

1) Pump Error Conditions, for example, where the pumping mechanism has stopped and a suitable sensor sends a pump stoppage signal to the processor.

2) High Pressure Alarm for Downstream Blockages, where a suitable pressure sensor sends a high pressure signal to the processor.

3) Upstream Occlusion Alarm, where a suitable pressure sensor sends an occlusion signal to the processor.

4) Any Fluid Reservoir Removal Event, where a suitable sensor sends a reservoir removed signal to the processor.

5) Any Fluid Reservoir Attached Event, where a suitable signal is sent to the processor by a suitable sensor, possibly

the same sensor as the sensor for sensing a reservoir removed event.

6) Any Internal Battery Event, where a suitable sensor senses whether the battery has been changed, is low, or is depleted.

7) Any AC Adaptor Event, where a suitable sensor senses whether the adapter is connected, disconnected, or unplugged from the wall outlet.

8) Any portable Power Pack Event, where a suitable sensor senses whether the power pack is connected, disconnected, or depleted.

9) Any Remote Dose Cord Event (which permits patient to remotely press a key, such as the DOSE key on the keypad), where a suitable sensor senses whether the dose cord is connected or disconnected.

10) Any Communications Cable Event (to permit the pump to communicate with a printer, another pump or a computer), where a suitable sensor senses whether the cable is connected or disconnected.

11) Anytime the Device is Successfully Stopped or Started with START/STOP key, where a suitable sensor senses whether the pump is successfully stopped or started after the key is pressed.

12) Any Lock Level Change and the New Lock Level, in situations where the amount of access to the processor by the patient is changed, i.e. full access, some access, no access.

13) Any Patient Pump Operational Program Change or Status Reset/Clear in the New Program.

14) Anytime the PRIME key is used and how much fluid is primed to get air out of the pump, such as during pump start up.

15) Any Patient Dose Delivered and the Amount Delivered by the patient hitting the DOSE key to manually give the patient an additional amount of fluid.

16) Any Change in Other Features (units, time or date set, auto lock change, application change) and the New Data or State.

17) Anytime the Pump is Successfully Recertified.

18) Number of Activations of Pumping Mechanism and Duration of Use.

Various functions are anticipated for each of the keys on each pump **20**,**40**. Each key has at least one function. Examples of potential functions of the different keys include:

1) A NEXT SCREEN key to move through the various screens by running a next screen program;

2) An ENTER/CLEAR key;

3) AN UP ARROW key and a DOWN ARROW key for paging through what is displayed on the screen with a highlight bar, or to page through numeric values to highlight and/or display the desired value;

4) A PRIME key to run a pump prime program to prime the pump;

5) A START/STOP key for operating a pump start program and a pump stop program;

6) A LOCK key for providing access control to the processor through an access program;

7) A DOSE key to run a patient pump control program for permitting patient control of the pumping mechanism;

8) A HELP key for providing help information on the display.

Referring now to FIG. **9**, a monitor or computer screen **90** is shown, as another embodiment of the invention. An image of a pump **92** (front view) is displayed on screen **90** through suitable graphics capability. Screen **90** is operatively interconnected with a processor of computer system, such as the processor of computer **80**. The image **92** on screen **90** is able to be manipulated as if it were a pump through the use of a screen interactive program utilizing a mouse or a touch screen. Computer **80** is programmed to run various programs depending on how the various keys **94** of pump image **92** are pressed through the use of the mouse or the touch screen. This permits simulation of the pump **20** with the use of a computer **80**. Display area **95** may then display information like display **26** of pump **20**.

Computer screen **90** and computer **80** are utilized to communicate with a pump located at a remote site, like pump **64** of FIG. **2**. If the pump is located locally, like pump **62** of FIG. **2**, then communication is direct with a straight through pass as shown in FIGS. **2** and **3**.

The arrangement involving the computer screen of FIG. **9** is useful when the caregiver is communicating with a patient pump at a remote location or at a local location. The caregiver can more easily use the computer system since the caregiver is already familiar with the operation of a pump through the use of the keys and the display. Activating the keys **94** of the image **92** and using the display **95** of the pump image simulates for the caregiver the presence of an actual pump. This facilitates reductions in training time for training the caregiver to communicate with the patient's pump, since the caregiver is most likely already familiar with operation of the patient's pump.

The computer system with the pump image program may also be used as a simulator for training the caregiver and/or the patient how to use the pump. The simulator includes various programs for simulating operation of a patient's pump to pump fluid. The simulator also includes various programs for simulating various communication situations with a patient's pump.

As shown in FIG. **10**, a computer screen **96** of a training simulator system is shown. On computer screen **100**, pump image **92** and simulator information **98** are displayed. Simulator information is used to select various conditions through simulator programs for simulating a operation of a patient pump. Pump **92** could function as a caregiver pump to permit training of a caregiver on how to use the caregiver pump to communicate with a patient pump. For example, if the caregiver trainee wanted to simulate a communications session with a remote patient pump that had a low battery, for example, the caregiver trainee would select the program in listing **98** that would simulate a pump to pump communications situation where the caregiver would trouble shoot the patient pump to determine that a low battery situation existed. The simulator also has a simulator program for simulating at least some of the sequences to connect and disconnect the pumps according to the flow charts of FIGS. **6**A, **6**B, **7**, and **8**.

The simulator system also includes simulation programs in information **98** for simulating operation of the pump on the screen **96** as a patient pump to pump fluid to a patient. This would be useful for training a patient and a caregiver how to operate the pump in the normal pumping mode.

The present invention relates specifically to a pump communication simulator for training a pump operator comprising: a computer system including processor means, and display means electrically interconnected to the processor means of the computer system; first program means for displaying an image of the pump on the display means, the image having an input region and a display region; second program means for permitting manipulation of the input

region of the image of the pump on the display means by the pump operator such that access to the processor means of the computer system is achieved; and third program means for sending a predetermined message to the display region of the image of the pump in response to manipulations of the input region of the image by the pump operator.

The invention is not to be construed as to be limited by the specific embodiments described above or shown in the drawings, but is to be limited only by the broad general meaning of the following claims.

What is claimed is:

1. A pump to pump communication system comprising:

(a) a local pump and a remote pump, each of the local and remote pumps including:

(i) a pumping mechanism;

(ii) processor means including means for controlling operation of the pumping mechanism;

(iii) operator input means for making an operator input of information to the processor means;

(iv) display means for displaying information from the processor means; and

(v) a communications cable sensor;

(b) local and remote modems, and local and remote modem cables connecting the respective local and remote modems to the respective local and remote pumps;

(c) modem connect means for connecting the local and remote modems;

(d) first input signal program means associated with the processor means of the local pump for sending an operator's input signal from the operator input means of the local pump to the remote pump;

(e) second input signal program means associated with the processor means of the remote pump for receiving the operator's input signal from the local pump;

(f) first display signal program means associated with the processor means of the remote pump for sending a display signal from the processor means of the remote pump to the local pump;

(g) second display signal program means associated with the processor means of the local pump for receiving the display signal from the remote pump;

(h) disabling program means associated with the processor means of the remote pump for disabling the pumping mechanism of the remote pump during communication between the local and remote pumps over the modem connect means;

(i) remote pump paging signal program means associated with the processor means of the remote pump for sending an operator's input signal from the operator input means of the remote pump to the local pump;

(j) local pump paging signal program means associated with the processor means of the local pump for receiving the operator's input signal from the remote pump;

(k) unlock program means associated with the processor means of the remote pump for unlocking access to the processor of the remote pump in response to the operator's input signal received from the local pump;

(l) automatic lock program means associated with the processor means of the remote pump for locking access to the processor means of the remote pump after communication between the local and remote pumps over the modem connect means; and

(m) first pump operation program means associated with the processor means of the remote pump for operating the pumping mechanism of the remote pump when the remote pump is disconnected from the remote modem cable.

2. The communication system of claim **1**, further comprising second pump operation program means associated with the processor means of the local pump for operating the pumping mechanism of the local pump in a different manner than the remote pump when the local pump is disconnected from the local modem cable.

3. A method of communicating with a remote pump comprising the steps of:

(a) providing a local pump having a keyboard and a display, a local modem, a local telephone, and a local communications cable;

(b) providing the remote pump having a keyboard and a display, a remote modem, a remote telephone, and a remote communications cable;

(c) connecting the local pump to the local modem with the local communications cable;

(d) connecting the remote pump to the remote modem with the remote communications cable;

(e) sending an audible signal from the local telephone to the remote telephone;

(f) sending a keyboard input signal from the local pump to the remote pump;

(g) in response to the keyboard input signal from the local pump in step (f), sending a display signal from the remote pump to the local pump;

(h) displaying the display signal from the remote pump in step (g) on the display of the local pump; and

(i) disconnecting the local and remote communications cables from the local and remote pumps, respectively.

4. The method of claim **3**, after step (i), further comprising the step of sending a further audible signal from the local telephone to the remote telephone.

5. The method of claim **3**, before step (i), further comprising the step of sending a keyboard input signal from the remote pump to the local pump.

6. The method of claim **3**, before step (i), further comprising the step of sending a further keyboard input signal from the local pump to the remote pump, the further keyboard input signal changing an operating program in the remote pump.

7. The method of claim **3**, further comprising the step of masking predetermined keys of the keyboard of the remote pump during pump to pump communication.

8. The method of claim **3**, further comprising the steps of:

(a) unlocking an access code lock of the remote pump by sending an access unlock keyboard input signal from the local pump to the remote pump; and

(b) relocking the access code lock of the remote pump after pump to pump communication.

9. The method of claim **8**, wherein the remote pump includes automatic relock program means for automatically relocking the access code lock, the method further comprising the step of automatically relocking the access code lock.

10. The method of claim **3**, wherein the remote pump includes disabling program means for disabling a pumping mechanism of the remote pump, the method further comprising the step of disabling the pumping mechanism of the remote pump during pump to pump communication.

11. The method of claim **3**, wherein each of the local and remote pumps includes a communications cable sensor, the method further comprising the steps of:

(a) sensing the remote communications cable with the cable sensor of the remote pump;

(b) sending a signal from the cable sensor of the remote pump to a controller of the remote pump that the remote cable has been sensed;

(c) sensing the local communications cable with the cable sensor of the local pump; and

(d) sending a signal from the cable sensor of the local pump to a controller of the local pump that the local cable has been sensed.

12. The method of claim **3**, after step (i), further comprising the steps of pumping fluid to a first patient with the remote pump and pumping fluid to a different patient with the local pump.

13. The method of claim **12**, wherein the local and remote pumps each include an operating program for pumping fluid, the operating program used to pump fluid with the local pump being different than the operating program used to pump fluid with the remote pump.

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